Recreational Vehicle Batteries
A Practical Guide

Version 3

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Disclaimer

- I am not a technical expert with regard to batteries.
- I do have many years of real-world battery experience – vehicles, boats, houseboats, recreational vehicles, etc.
- I have yet to meet the person who knows everything there is to know about batteries.
- As a “Practical Guide,” this presentation will attempt to convey what we need to know, not all there is to know.

Additional Disclaimers

- **We will focus primarily on Tiffin motorhomes.**
- **Most of what follows is applicable to other brands of motorhomes.**
- **A good portion of what follows is applicable to other forms of recreational vehicles – fifth-wheel trailers, pull trailers, etc.**
- **Corrections and clarifications are welcome and appreciated!**

Which Batteries Are We Talking About?

- **Tiffin motorhomes are typically equipped with one or two engine starting batteries. These engine starting batteries are referred to as Chassis Batteries.**

- **Tiffin motorhomes are typically equipped with two or more batteries that supply power to the "house" portion of the motorhome. Hence these batteries are referred to as House Batteries.**

- **These Chassis Batteries and House Batteries are the subject of this presentation.**

Distinguishing Characteristics of RV Batteries

RV Batteries Can Be…

- 6 Volt or 12 Volt
- Flooded Cell, Absorbed Glass Mat (AGM), Gel, or Lithium-Ion
- Starting, Deep Cycle, or Dual Purpose
- Different Battery Council International (BCI) Group Sizes

Let's explore these characteristics in more detail…

6 Volt Batteries Versus 12 Volt Batteries

6 Volt Versus 12 Volt Batteries

- **6 Volt Batteries and 12 Volt Batteries are both made up of multiple cells.**
- **Each cell, when fully charged, produces a little over 2.1 volts (except Lithium-Ion).**
- **A 6 Volt Battery has three cells and will measure close to 6.4 volts at full charge (no load, resting voltage).**
- **A 12 Volt Battery has six cells and will measure between 12.7 and 12.8 volts at full charge (no load, resting voltage).**

6 Volt Versus 12 Volt Batteries (Continued)

- **6 Volt Batteries are typically used in RV House Battery applications.**
- **6 Volt Batteries are virtually never used in RV Chassis Battery applications.**
- **12 Volt Batteries are typically used in RV Chassis Battery applications.**
- **12 Volt Batteries are sometimes used in RV House Battery applications, but are not ideal for that purpose.**

6 Volt Versus 12 Volt Batteries (Continued)

- **All battery loads in recreational vehicles need 12 Volt power.**
- **So why do RV manufacturers install 6 Volt House Batteries?**
- **Because pairs of 6 Volt Batteries, cabled in series to produce 12 Volts, have significantly more capacity per cubic inch of space and pounds of weight than 12 Volt Batteries. (More info in Appendix B.)**

Flooded Cell Batteries Versus AGM Batteries Versus Gel Batteries Versus Lithium-Ion Batteries

Flooded Cell Batteries

- Flooded Cell Batteries (also referred to as Wet Cell Batteries) have lead plates that are submerged in a solution of 35% sulfuric acid and 65% water.

- This solution is referred to as electrolyte.

- Flooded Cell Batteries may be Serviceable or Maintenance Free (Non-Serviceable).

- Serviceable Flooded Cell Batteries have removable cell caps to allow checking and replenishment of the electrolyte.

Flooded Cell Batteries (Continued)

- **Maintenance Free Flooded Cell Batteries have sealed tops that do not allow checking or replenishment of the electrolyte.**

- **Maintenance Free 12 Volt Flooded Cell Batteries are typically installed by Tiffin and other RV manufacturers as Chassis Batteries.**

- **Serviceable 6 Volt Flooded Cell Batteries are typically installed by Tiffin and other RV manufacturers as House Batteries.**

Flooded Cell Batteries (Continued)

Advantages of Flooded Cell Batteries:

- **Most bang for the buck – significantly less expensive than AGM, Gel or Lithium-Ion Batteries**
- **Relatively tolerant of total discharge**
- **Readily available from a wide variety of manufacturers and retailers**

Flooded Cell Batteries (Continued)

Disadvantages of Flooded Cell Batteries:

- **Require frequent attention (Serviceable)**
- **Messy, especially if charging profile is not correct (Serviceable)**
- **Not kind to clothes**
- **Lose charge faster than AGM Batteries when sitting idle/disconnected**
- **Destroyed if frozen**

Flooded Cell Batteries (Continued)

Example - Maintenance Free 12 Volt Flooded Cell Battery currently installed by Tiffin for Chassis power (Powerglide Bus chassis):

Flooded Cell Batteries (Continued)

Example – Serviceable 6 Volt Flooded Cell Battery currently installed by Tiffin for House power:

Absorbed Glass Mat (AGM) Batteries

- **Like Flooded Cell Batteries, AGM Batteries have lead plates and electrolyte, but the electrolyte in AGM Batteries is suspended in a material (the glass mat) similar in concept to a sponge.**

- **AGM Batteries will not spill electrolyte, even if turned upside down.**

- **AGM Batteries are sealed and as such are Maintenance Free.**

Absorbed Glass Mat (AGM) Batteries (Continued)

- **Like Flooded Cell Batteries, AGM Batteries are available in 6 volt and 12 volt models.**
- **Like Flooded Cell Batteries, AGM Batteries can be designed by the manufacturer as starting batteries or deep cycle batteries.**
- **Deep Cycle AGM Batteries have become increasingly popular for RV House Battery bank applications.**

Absorbed Glass Mat (AGM) Batteries (Continued)

Advantages of AGM Batteries:

- **Require virtually no attention once installed**
- **Can be handled and transported safely and without concern for leakage**
- **Lose charge significantly slower than Flooded Cell Batteries when sitting idle or disconnected**
- **Not damaged by freezing temperatures**

Absorbed Glass Mat (AGM) Batteries (Continued)

Disadvantages of AGM Batteries:

- **Considerably more expensive than an equivalent capacity Flooded Cell Battery**
- **Cost differential is larger for House Batteries than for Chassis Batteries**
- **Not especially tolerant of total discharge**
- **Fewer manufacturers and retailers than Flooded Cell Batteries**

Absorbed Glass Mat (AGM) Batteries (Continued)

Example - 6 Volt AGM Batteries frequently installed by Tiffin owners (and now Tiffin) for House Power:

Absorbed Glass Mat (AGM) Batteries (Continued)

Example - 12 Volt AGM Battery previously installed by Tiffin for House Power in Zephyr motorhomes:

Absorbed Glass Mat (AGM) Batteries (Continued)

Example - 12 Volt AGM Battery often installed as a replacement starting battery in cars and trucks:

Gel Batteries

- **Like Flooded Cell Batteries and AGM Batteries, Gel Batteries have lead plates and electrolyte, but the electrolyte in Gel Batteries includes an additive that causes it to approach solidification.**

- **Gel Batteries are sealed and as such are Maintenance Free.**

- **As Absorbed Glass Mat (AGM) Batteries have become more popular, Gel Batteries have faded from use in RV applications.**

Lithium-Ion Batteries

- **Lithium-Ion Batteries are a promising but relatively leading-edge technology for recreational vehicle applications.**

- **The original Lithium-Ion Battery chemistry was Lithium Cobalt Oxide (LiCoO2). LiCoO2 batteries are susceptible to thermal runaway and fire if overcharged.**

- **A more recent (and safer) Lithium-Ion Battery chemistry is Lithium Iron Phosphate (LiFePO4 or LFP for short).**

Lithium-Ion Batteries (Continued)

- **Unlike the 2.1 volt cells in Flooded Cell, AGM and Gel Batteries, the cells in LFP Batteries produce about 3.2 volts per cell.**

- **As such, four LFP cells are connected in series to yield a 12 Volt Battery.**

- **As with Flooded Cell, AGM and Gel Batteries, multiple 12 Volt Lithium-Ion Batteries can be connected in parallel to yield additional capacity.**

Lithium-Ion Batteries (Continued)

- **Individual LFP cells, virtually all of which are currently made in China, can be purchased by sufficiently knowledgeable Do-It-Yourselfers and assembled into a 12 Volt package for installation in a recreational vehicle.**

Or…

- **Several companies are currently offering pre-packaged LFP configurations which typically include under and over voltage protection and other desirable features and functionality.**

Lithium-Ion Batteries (Continued)

- **Before embarking on an installation of Lithium-Ion batteries in a recreational vehicle, be sure to do your homework.**

- **An excellent overview of a motorhome-related Lithium-Ion battery project written by Chris Dunphy is available at: www.technomadia.com/lithium.**

- **For the most recent info on this project, go to: www.technomadia.com/2015/02/living-the-lithium-lifestyle-3-5-year-lithium-rv-battery-update.**

Lithium-Ion Batteries (Continued)

- **An overview of a similar project written by Ron Jones is available at: www.aboutrving.com/category/lithium-ion-batteries.**

- **Both authors received manufacturer support; Jones more so than Dunphy.**

- **Information on Lithium-Ion Batteries is also available in recent issues of Motorhome Magazine – January 2016, pages 75 & 76; February 2016, pages 40–46.**

Lithium-Ion Batteries (Continued)

Advantages of Lithium-Ion Batteries:

- **Like AGM and Gel Batteries, Lithium-Ion Batteries are sealed and virtually Maintenance Free**
- **Significantly lighter than other batteries of comparable rated capacity**
- **80% or more of rated capacity can be used before recharging with no impact on battery life (versus 50% for other battery types)**

Lithium-Ion Batteries (Continued)

Advantages of Lithium-Ion Batteries (continued):

- **No fall off in voltage until 80% to 90% of capacity is utilized**
- **Faster recharge than other battery types – less generator run time when boondocking**
- **Rated for significantly more cycles than other battery types, theoretically yielding longer battery life (but not necessarily validated by early adopters)**

Lithium-Ion Batteries (Continued)

Disadvantages of Lithium-Ion Batteries:

- **Voltage drops quickly as battery nears depletion; fully discharging (even once) can ruin the battery**
- **Additional, more sophisticated monitoring/ management equipment may be required**
- **Battery monitors and auto-generator start systems which rely on battery voltage may not work as intended**

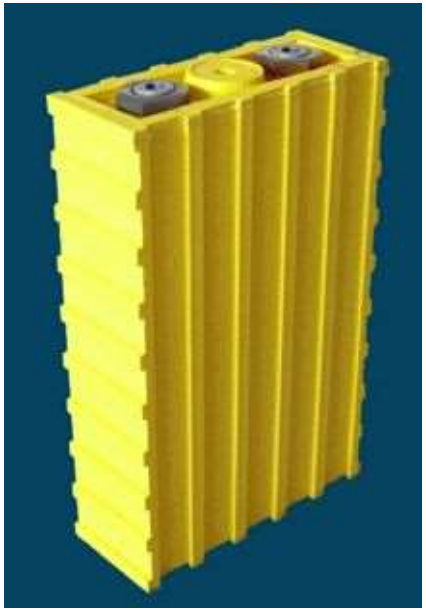
Lithium-Ion Batteries (Continued)

Disadvantages of Lithium-Ion Batteries (continued):

- **Most inverter/chargers do not have charging profiles for Lithium-Ion Batteries**
- **All cells in a configuration need to be precisely balanced before use**
- **Cost/Complexity – Potentially beneficial for hard-core boondockers; others probably better off with more traditional battery types**

Lithium-Ion Batteries (Continued)

Example – A Balqon LFP cell and a Balqon 12 Volt LFP package with external protection equipment:



Lithium-Ion Batteries (Continued)

Example – A Smart Battery 12 Volt LFP package with enclosed protection equipment:

Lithium-Ion Batteries (Continued)

Example – A Lithionics 12 Volt LFP package with enclosed protection equipment installed in a 2014 Tiffin Allegro Bus:

Starting Batteries Versus Deep Cycle Batteries Versus Dual Purpose Batteries

Starting Batteries

- Starting Batteries are designed to deliver a large burst of power for a short period of time – exactly what we need to start an engine.

- Starting Batteries are not particularly tolerant of being deeply discharged more than a few times.

- As such, Starting Batteries are not well suited for RV House Battery applications.

Deep Cycle Batteries

- **Deep Cycle Batteries are designed to deliver relatively small amounts of power over a longer period of time – just what we need in RV House Battery applications.**

- **Deep Cycle Batteries can be repeatedly discharged and recharged.**

- **The discharge and subsequent recharge of a Deep Cycle Battery is referred to as one cycle. Deep Cycle Batteries can tolerate hundreds of these cycles.**

Dual Purpose Batteries

- **Dual Purpose Batteries are usually Starting Batteries with limited Deep Cycle Capability.**

- **Dual Purpose Batteries can tolerate more discharge/recharge cycles than Starting Batteries, but not a lot more.**

- **As such, Dual Purpose Batteries (like the Optima D31M pictured earlier) are not well suited for RV House Battery applications unless the owner rarely or never dry camps.**

BCI Groups

BCI Groups

- BCI = Battery Council International
- BCI Group Numbers refer to the external dimensions of batteries in a particular Group. For example…
- The 6 Volt House Batteries installed by Tiffin and other RV manufacturers are usually BCI Group GC2. These batteries have a foot print of approximately 10 & 1/4” x 7 & 1/8” and are typically about 11” tall.

BCI Groups (Continued)

- Similarly, the 12 Volt Chassis Batteries installed in Tiffin's Powerglide Bus chassis and similar diesel chassis from Freightliner and Spartan are usually BCI Group 31. These batteries have a footprint of approximately 13" x 6 & 3/4" and are about 9 & 1/4" tall.

- The height of different brands of batteries in a given BCI Group will vary more than the footprint dimensions.

A Closer Look at Chassis Batteries

Chassis Batteries

- Chassis Batteries are normally provided by the manufacturer of the motorhome's chassis – Ford, Freightliner, Powerglide, Spartan, etc.

- The chassis manufacturers nearly always install 12 Volt Maintenance Free (Non-Serviceable) Chassis Batteries (one or two).

- The primary function of the Chassis Batteries is to start the motorhome's engine.

Chassis Batteries (Continued)

- Chassis Batteries also provide power to various other loads, similar to the engine starting battery in a car – headlights, radio, dash heater, dash air conditioner, etc.

- Commonly installed brands of motorhome Chassis Batteries include Motorcraft (Ford), Alliance (Freightliner), Interstate (earlier Powerglide), East Penn/Deka (newer Powerglide), and Harris (Spartan).

Chassis Batteries (Continued)

- **Chassis Batteries are “happiest” and last longest if kept fully charged at all times.**

- **Anytime the engine is running, the engine-driven alternator will keep the Chassis Batteries charged up.**

- **When the coach is plugged into shore power or has its generator running, a Battery Minder, Trik-L-Start, Amp-L-Start, or similar device will keep the Chassis Batteries topped off.**

Chassis Batteries (Continued)

- Chassis Batteries suffer when the coach is parked for extended periods of time without shore power or generator power.

- Turning off the Chassis Battery disconnect switch helps in these situations, but usually does not disconnect all loads.

- On coaches equipped with early versions of the Battery Minder, it is important to realize the Battery Minder will actually draw down the Chassis Batteries when shore power or generator power is not present.

Chassis Batteries (Continued)

- To avoid the problem of the Battery Minder drawing down the Chassis Batteries when shore power or generator power is not present, the Battery Minder's inline fuse can be pulled. (Unplugging the Battery Minder will not stop the draw down.)

- For coaches that must be stored for extended periods of time without shore power or generator power, a second disconnect switch can be added to disconnect all loads, or the main ground cable can be disconnected.

Chassis Batteries (Continued)

- **So, why would we replace the Chassis Batteries originally installed by the manufacturer of the motorhome's chassis?**

- **Usually only one reason: The Chassis Batteries can no longer deliver anything close to their original CCA capacity. This condition is usually indicated by slow or no engine cranking, and can be caused by age or repeated deep discharges (as will occur if the coach is parked for extended periods of time with no shore or generator power).**

Chassis Batteries (Continued)

- When replacing Chassis Batteries, the key specifications we care about are BCI Group Number and Cold Cranking Amps (CCA).
- As previously noted, the BCI Group Number identifies the dimensions of a given battery.
- Matching the BCI Group Number of the replacement batteries to the BCI Group Number of the old batteries ensures the new batteries will fit properly in the available space.

Chassis Batteries (Continued)

- CCA is an indication of how many amps a given battery can supply to the engine's starter at 0 (zero) degrees Fahrenheit.
- Replacement Chassis Batteries should have a CCA rating equal to or greater than the CCA rating of the original Chassis Batteries.
- You may also see a cranking amps rating at 32 degrees Fahrenheit, usually labeled Marine Cranking Amps (MCA).

Chassis Batteries (Continued)

Example – East Penn/Deka Model 1131MF Group 31, 950 CCA, Maintenance Free Chassis Battery (2) in recent coaches on a Powerglide Chassis):

Chassis Batteries (Continued)

Example – Interstate Model 31-MHD Group 31, 950 CCA, Maintenance Free Chassis Battery (2) in earlier coaches on a Powerglide Chassis:

Chassis Batteries (Continued)

Motorhome Chassis Battery brands with which I have experience and have been satisfied:

- **Alliance (Flooded Cell / Maintenance Free)**
- **Interstate (Flooded Cell / Maintenance Free)**
- **Optima Red Top and Yellow Top (AGM)**
- **East Penn/Deka**
- **NorthStar (similar to Odyssey)**

Chassis Batteries (Continued)

Motorhome Chassis Battery brands I have helped other owners select and/or install:

- **Duracell (Flooded Cell / Maintenance Free)**
- **Duracell (AGM)**
- **Energizer (Flooded Cell / Maintenance Free)**
- **Energizer (AGM)**
- **Lifeline (AGM)**

Chassis Batteries (Continued)

- Duracell branded batteries are sold at Sam's Club stores east of the Mississippi River and are made by East Penn Manufacturing Company – www.dekabatteries.com.

- Energizer branded batteries are sold at Sam's Club stores west of the Mississippi River and are made by Johnson Controls – www.johnsoncontrols.com.

- Costco stores are another source for Chassis Batteries, but may not carry the BCI Group size required for certain motorhomes.

Chassis Batteries (Continued)

Chassis Battery Replacement Recommendations:

- **For gas coaches with a single Chassis Battery, I believe the relatively modest extra cost for an AGM starting battery (Optima or similar) is money worth spending.**

- **For diesel coaches with two Chassis Batteries, the Maintenance Free Flooded Cell starting batteries like those installed by the chassis manufacturers are nearly always sufficient.**

Chassis Batteries (Continued)

Chassis Battery Replacement Recommendations (Continued):

- **For diesel coaches with Group 31 Chassis Batteries, the cost of AGM batteries can be more than twice the cost of Maintenance Free Flooded Cell batteries.**

- **If you are replacing Chassis Batteries in a diesel motorhome and intend to keep the coach a long time, spending the extra money to install AGM batteries may be a worthwhile investment.**

A Closer Look at House Batteries

House Batteries

- House Batteries are normally provided by the manufacturer of the motorhome – Tiffin, American Coach, Entegra, Newmar, etc.

- Tiffin and other manufacturers usually install 6 Volt Flooded Cell BCI Group GC2 House Batteries, although some offer 6 Volt AGM Batteries as standard or optional.

- 6 Volt Flooded Cell Batteries are always Serviceable, meaning they have removable caps. I am not aware of any Maintenance Free 6 Volt Flooded Cell GC2 Batteries.

House Batteries (Continued)

- Tiffin used to install 12 Volt AGM Batteries in the Zephyr but now offers Lifeline 6 Volt AGM Batteries on various product lines.

- In motorhomes without an inverter, the only function of the House Batteries is to provide power to the 12 Volt loads in the coach – lights, water pump, propane furnace, gas absorption refrigerator, etc.

- In motorhomes without an inverter, Tiffin will normally install one pair of 6 Volt Flooded Cell Batteries.

House Batteries (Continued)

- In motorhomes with an inverter, the House Batteries still provide power to the 12 Volt loads in the coach, but also provide power to the inverter which converts 12 Volt direct current (DC) power from the batteries into 120 Volt alternating current (AC) power.

- This 120 Volt AC power from the inverter allows the operation of various appliances and devices – TV's, residential refrigerator, microwave, etc. – when the coach is not connected to shore power or generator power.

House Batteries (Continued)

- In motorhomes with an inverter that do not have a residential refrigerator, Tiffin will normally install two pairs of 6 Volt Flooded Cell Batteries.

- In larger motorhomes with an inverter and a residential refrigerator, Tiffin will normally install three pairs of 6 Volt Flooded Cell Batteries.

- In most Tiffin motorhomes, the House Batteries are also used to start the generator.

House Batteries (Continued)

- For many years, Tiffin installed the Interstate brand of 6 Volt Flooded Cell Batteries for house power.

- More recently, Tiffin has been installing the U.S. Battery brand of 6 Volt Flooded Cell Batteries for house power.

- This change is not especially significant since U.S. Battery used to manufacture Interstate's 6 Volt Flooded Cell Batteries. (Interstate has since switched to Johnson Controls as their supplier of 6 Volt Batteries.)

House Batteries (Continued)

- Like Chassis Batteries, House Batteries benefit from being fully charged as frequently as possible, but are less adversely affected by repeated discharging.

- Dual Purpose Batteries are an exception. If they are installed for house power, repeated discharging should be avoided.

- As noted earlier, Dual Purpose Batteries should only be used for House Power if the owner will rarely or never dry camp.

House Batteries (Continued)

- Anytime the engine is running, the engine-driven alternator will keep the House Batteries charged up. This is accomplished through a charge solenoid which connects the House Batteries to the Chassis Batteries while the engine is running.

- Note that coaches on the earlier Powerglide chassis have a built-in 10 minute delay before the charge solenoid is energized. This delay is not present in coaches on the newer Powerglide chassis.

House Batteries (Continued)

- **For motorhomes without an inverter, the House Batteries will be charged by a Converter (basically a battery charger) anytime the coach is plugged into shore power or has its generator running.**

- **For motorhomes with an inverter, the House Batteries will be charged by the charger portion of the inverter anytime the coach is plugged into shore power or has its generator running.**

House Batteries (Continued)

- Some coaches may also be equipped with one or more solar panels to charge the House Batteries when sunlight is present.

- As noted earlier, House Batteries can tolerate repeated discharge/recharge cycles, but they do suffer if the coach is parked for extended periods of time without shore power or generator power.

- Turning off the House Battery disconnect switches helps, but these switches usually do not disconnect all loads.

House Batteries (Continued)

- For coaches that must be stored for extended periods of time without shore power or generator power, a second disconnect switch can be added to disconnect all loads, or the main ground cable can be disconnected.

- For very long periods of storage without shore power or generator power, removing all cables from the House Batteries will provide an additional measure of protection.

House Batteries (Continued)

- So, why would we replace the House Batteries originally installed by the manufacturer of the motorhome?

- Reason #1 – The House Batteries can no longer deliver anything close to their original AmpHour capacity. This condition is usually indicated by the House Battery bank dropping to low voltage significantly quicker than had originally been the case, and can be caused by age, neglect, or human error (e.g., forgetting to turn off the inverter when storing the coach.)

House Batteries (Continued)

- **Reason #2 – The House Batteries installed by the manufacturer of the motorhome do not have sufficient capacity to meet our particular dry camping needs or preferences. This condition is usually indicated by the House Battery bank being lower than we prefer to see after a night of dry camping without the generator running.**

- **Reason #3 – We prefer the cleanliness and no-maintenance convenience of AGM, Gel, or Lithium-Ion Batteries over Flooded Cell Batteries.**

House Batteries (Continued)

- When replacing House Batteries, the key specifications we care about are BCI Group Number and capacity ratings such as AmpHours and/or Reserve Capacity.

- As previously noted, the BCI Group Number identifies the dimensions of a given battery.

- Matching the BCI Group Number of the replacement batteries to the BCI Group Number of the old batteries ensures the new batteries will fit properly in the available space. However…

House Batteries (Continued)

- Since House Batteries usually occupy a larger space than Chassis Batteries, it may be viable to consider replacement batteries with a different BCI Group Number.

- Be cautious when considering this option, as switching to batteries with different dimensions will complicate the installation process.

- The simplest approach when replacing 6 Volt House Batteries is to select new batteries with a BCI Group GC2 footprint.

House Batteries (Continued)

- The AmpHour rating of a battery is an indication of its capacity to deliver power over time.
- Reserve Capacity is a somewhat similar indicator, and is a bit easier to understand.
- Rather than take the time & effort to explain these ratings in detail, let's focus on a few key points:

House Batteries (Continued)

- **More is better. A battery rated at 300 AmpHours has more capacity than a battery rated at 220 AmpHours.**

- **Similarly, a battery with a Reserve Capacity rating indicating 692 minutes of discharge at 25 amps has more capacity than a battery with a Reserve Capacity rating indicating 492 minutes of discharge at 25 amps.**

House Batteries (Continued)

- For our purposes, we can treat these ratings (AmpHours or Reserve Capacity) as linear. For example we can assume a battery rated at 300 AmpHours has about 35% more capacity than a battery rated at 220 AmpHours.

- Now let's look at how we determine the total AmpHour capacity of a given bank of House Batteries…

House Batteries (Continued)

- If we are using 12 Volt Batteries for our House Battery bank, all we need to do is multiply the AmpHour rating of one battery times the number of batteries in the bank.

- For example, back when Tiffin installed eight 12 Volt, 75 AmpHour, Optima D31M Blue Top batteries in a Zephyr, the capacity of the bank was 75 x 8 = 600 Amp Hours.

House Batteries (Continued)

- **If, as is more commonly the case, we are using 6 Volt Batteries for our House Battery bank, we need to keep in mind that the AmpHour rating of each battery is at 6 Volts, and that the 6 Volt Batteries will be cabled in pairs to produce 12 volts.**

- **When we do that, the AmpHour rating of each pair at 12 Volts will be the same as the AmpHour rating of an individual battery at 6 Volts.**

House Batteries (Continued)

- To illustrate, consider the House Battery bank Tiffin is currently installing in most Allegro Bus motorhomes – six 6 Volt, 216 AmpHour, U.S. Battery 2000 XC2 batteries.

- This configuration has three pairs of batteries, with each pair capable of delivering 216 AmpHours at 12 volts, so the capacity of the bank is 3 x 216 = 648 AmpHours (not 6 x 216 = 1296 AmpHours).

House Batteries (Continued)

Example – Six 6 Volt U.S. Battery Model 2000 XC2, 216 AmpHour, Group GC2, Flooded Cell House Batteries in 2014 Bus:

House Batteries (Continued)

Example – Eight 12 Volt Optima Model D31M, 75 AmpHour, Group 31, AGM House Batteries in 2014 Zephyr:

House Batteries (Continued)

Example – Six 6 Volt Lifeline Model GPL-6CT, 300 AmpHour, Group GC2 Footprint, AGM House Batteries in our 2010 Bus:

House Batteries (Continued)

Example – Six 6 Volt Lifeline Model GPL-6CT, 300 AmpHour, Group GC2 Footprint, AGM House Batteries in a 2016 Bus:

House Batteries (Continued)

Motorhome House Battery brands with which I have experience and have been satisfied:

- **Crown (Flooded Cell / Serviceable)**
- **Interstate (Flooded Cell / Serviceable)**
- **Lifeline (AGM)**
- **Trojan (Flooded Cell / Serviceable)**
- **U.S. Battery (Flooded Cell / Serviceable)**

House Batteries (Continued)

Motorhome House Battery brands I have helped other owners select and/or install:

- **Duracell (Flooded Cell / Maintenance Free)**
- **Duracell (AGM)**
- **Energizer (Flooded Cell / Maintenance Free)**
- **Energizer (AGM)**

House Batteries (Continued)

House Battery Replacement Recommendations:

- **When replacing House Batteries, there are two key decisions – Flooded Cell versus AGM, and Same Capacity versus More Capacity.**

- **Flooded Cell versus AGM is very much an individual preference. AGM Batteries have various advantages, but are considerably more expensive than Flooded Cell Batteries.**

- **No right or wrong answer – pay your money and take your choice.**

House Batteries (Continued)

House Battery Replacement Recommendations (Continued):

- **Regarding Same Capacity versus More Capacity, one reason to increase House Battery bank capacity is to increase the time you can operate in a dry camping situation without starting your generator. But…**

- **Keep in mind, a higher capacity House Battery bank will take longer to recharge once you do have to start the generator.**

House Batteries (Continued)

House Battery Replacement Recommendations (Continued):

- **Another reason to increase House Battery capacity is to minimize the degree to which the battery bank is drawn down during periods when generator use is prohibited. That is advantageous because…**

- **The less you draw down a given battery bank before recharging, the longer the batteries will last.**

House Batteries (Continued)

House Battery Replacement Recommendations (Continued):

- **When opting for more capacity you can install additional batteries, if you have sufficient floor space.**

- **Alternatively, you can install taller batteries with the same footprint as those you are replacing, if you have sufficient head room. (This option is what I chose for our 2010 Bus.)**

Maximizing Battery Life

Maximizing Battery Life

- **If at all possible, keep the coach connected to shore power when not in use. If that is not possible…**

- **Take the steps outlined earlier in this presentation to minimize the discharge of your batteries while the coach is sitting idle. And…**

- **Visit the coach at least once a month to run the generator for at least an hour, preferably longer.**

Maximizing Battery Life (Continued)

- **Consider replacing the Battery Minder (Chassis Battery maintainer) with a product like the Trik-L-Start or Amp-L-Start from LSL Products – www.lslproducts.net.**

- **When dry camping, start your generator sooner rather than later to recharge the House Battery bank. Deep Cycle Batteries will last longer if discharged less.**

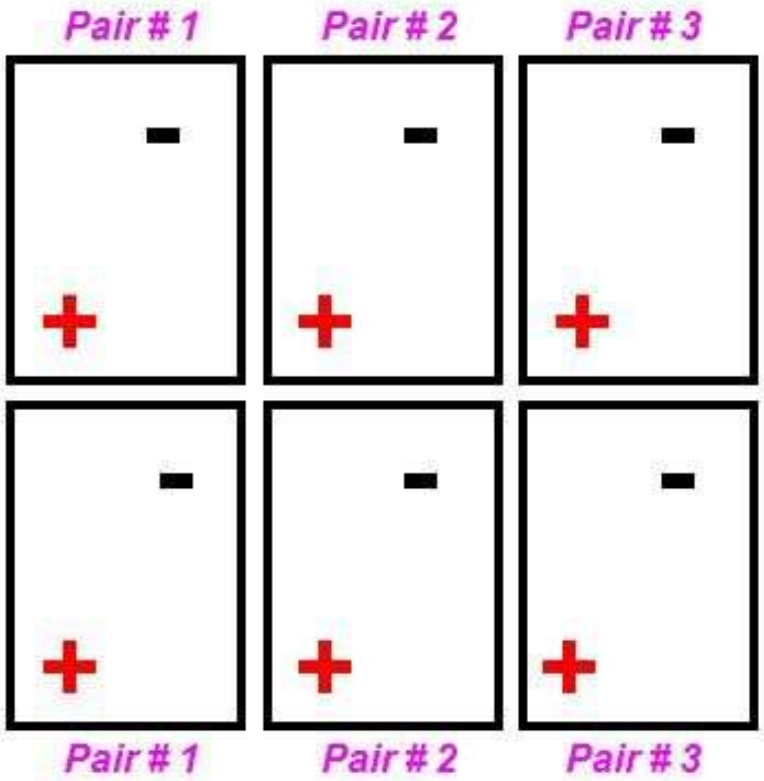
- **Check all batteries regularly and maintain as necessary.**

Appendix A
Series-Parallel Wiring Diagrams

6-Volt Batteries – Series/Parallel Wiring Diagram

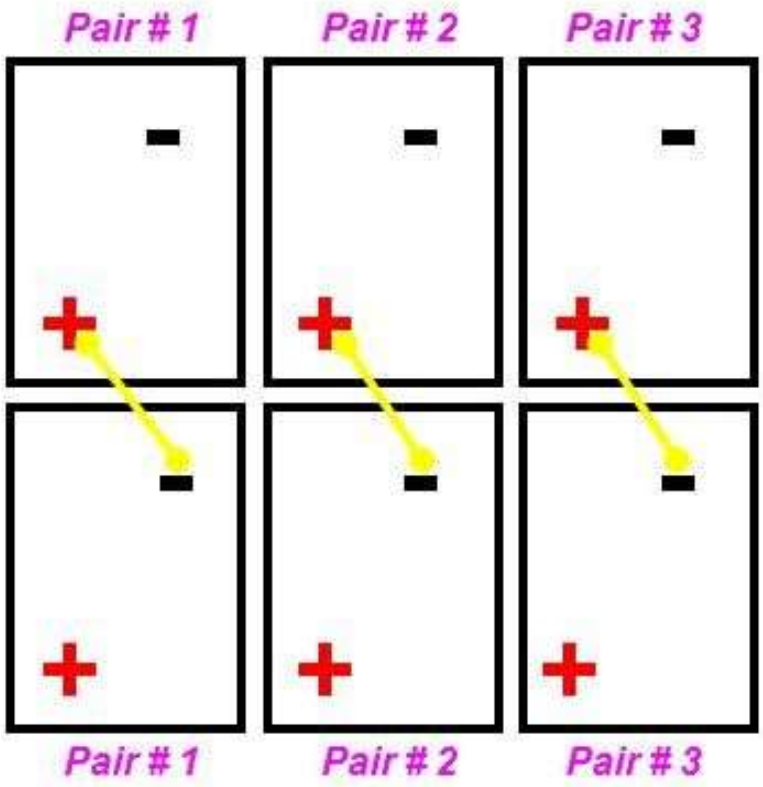
Step 0 – No Cables Connected

Yellow = Series Connections
Red = Positive Parallel Connections
Black – Negative Parallel Connections



6-Volt Batteries – Series/Parallel Wiring Diagram
Step 1 – Connect Interconnect (Series) Cables

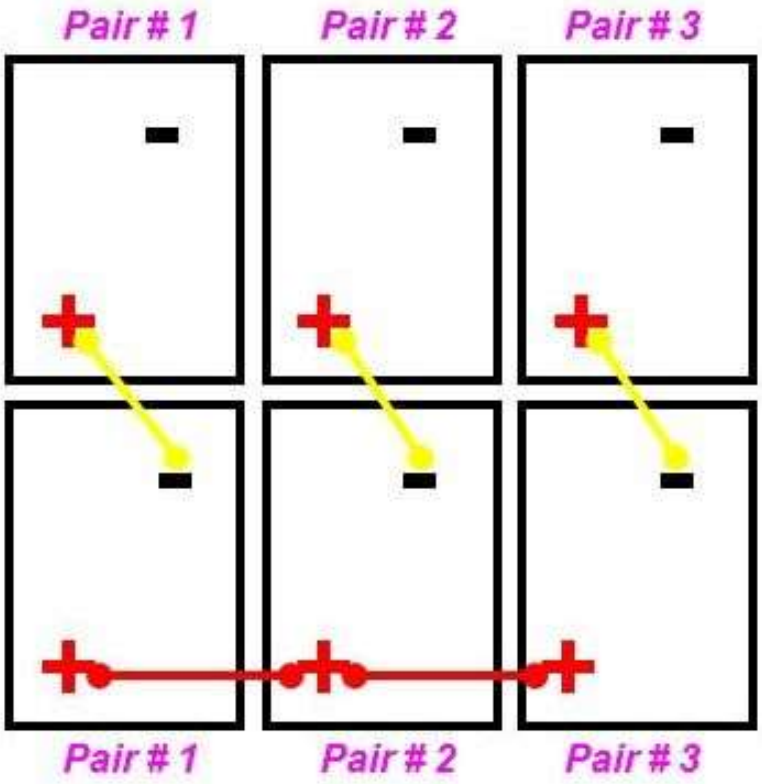
Yellow = Series Connections
Red = Positive Parallel Connections
Black – Negative Parallel Connections



6-Volt Batteries – Series/Parallel Wiring Diagram

Step 2 – Connect Positive Parallel Cables

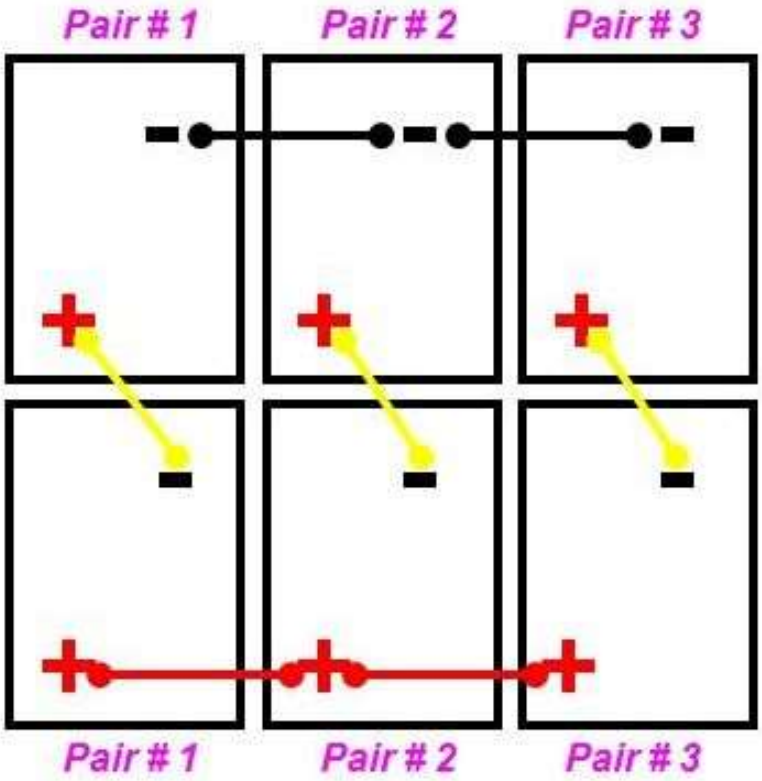
Yellow = Series Connections
Red = Positive Parallel Connections
Black – Negative Parallel Connections



6-Volt Batteries – Series/Parallel Wiring Diagram

Step 3 – Connect Negative Parallel Cables

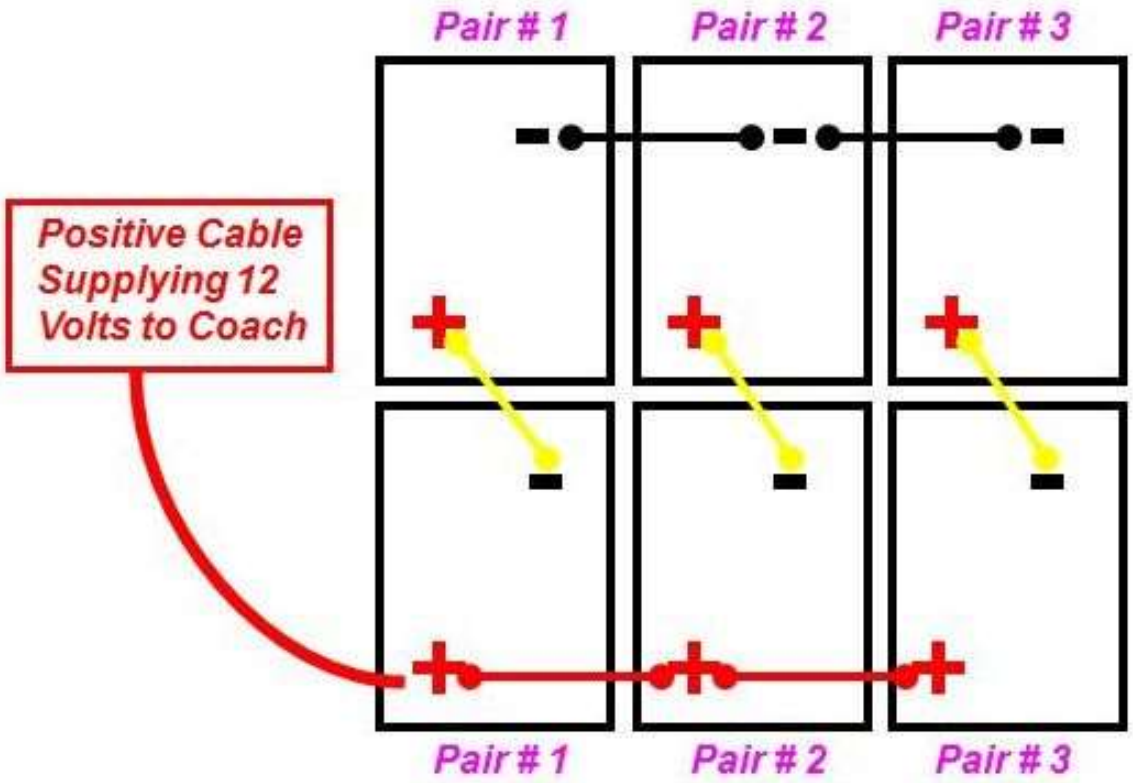
Yellow = Series Connections
Red = Positive Parallel Connections
Black – Negative Parallel Connections



6-Volt Batteries – Series/Parallel Wiring Diagram

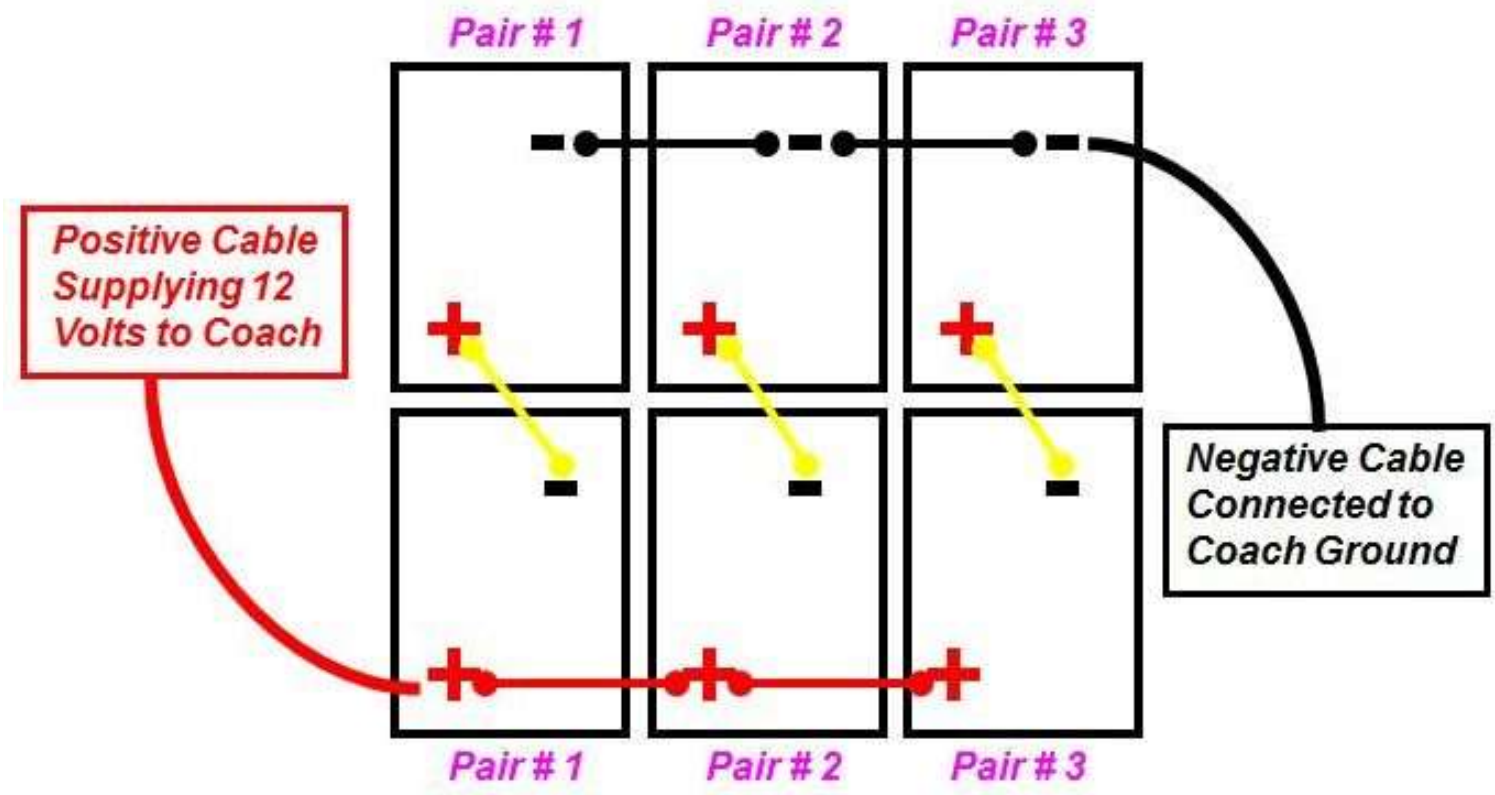
Step 4 – Connect Main Positive (Hot) Cable

Yellow = Series Connections
Red = Positive Parallel Connections
Black – Negative Parallel Connections



6-Volt Batteries – Series/Parallel Wiring Diagram
Step 5 – Connect Main Negative (Ground) Cable

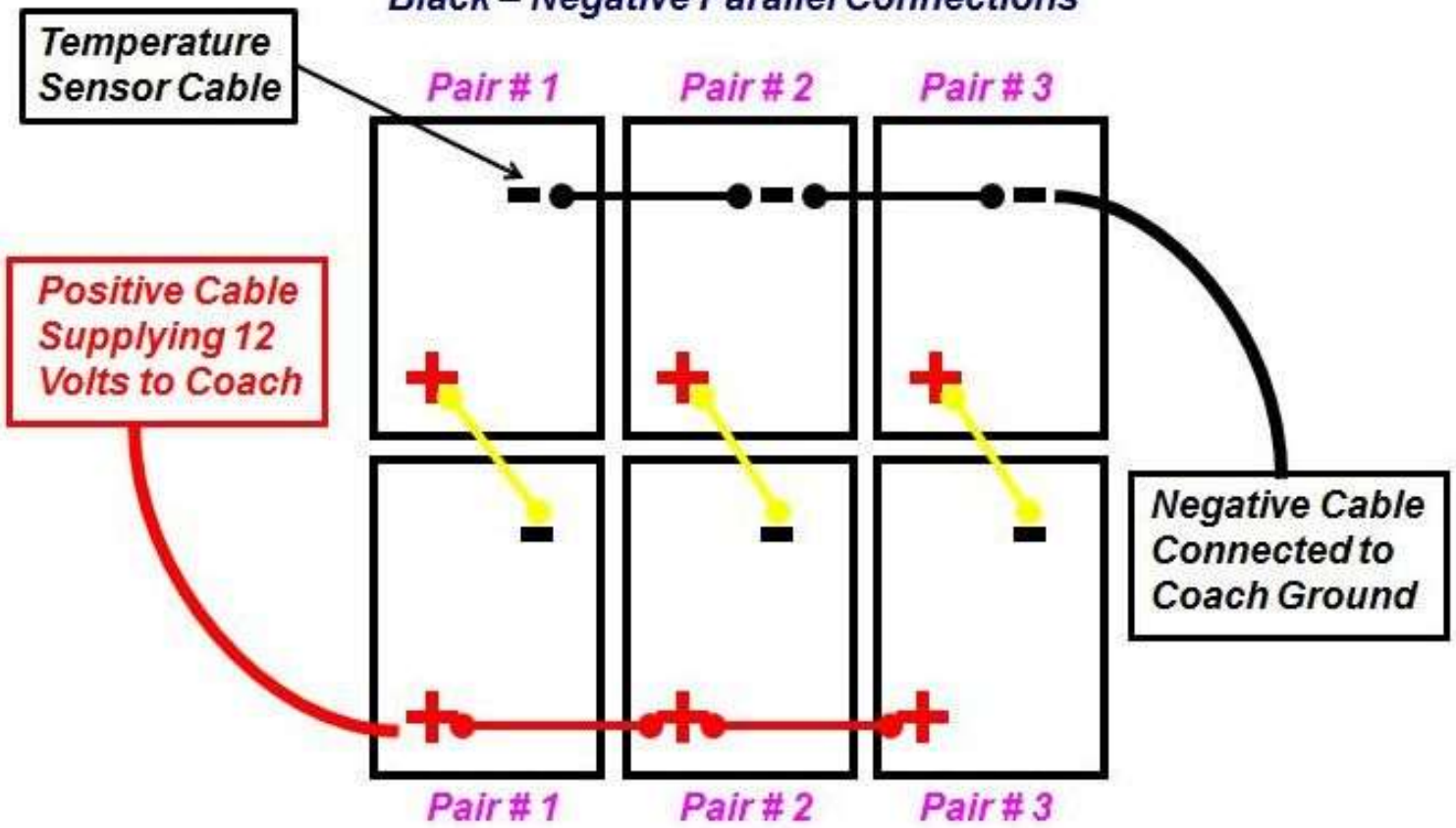
Yellow = Series Connections
Red = Positive Parallel Connections
Black – Negative Parallel Connections



6-Volt Batteries – Series/Parallel Wiring Diagram

Step 6 – Connect Temperature Sensor Cable

Yellow = Series Connections
Red = Positive Parallel Connections
Black – Negative Parallel Connections



Appendix B
Comparison of 6 Volt Versus 12 Volt House Batteries

6 Volt Versus 12 Volt House Batteries

- Let's assume we need a house battery bank with a capacity of 600 to 700 AmpHours.
- In the Allegro Bus, Tiffin meets this need with six 6 Volt U.S. Battery 2000 XC2 batteries which provide 648 AmpHours of capacity.
- This configuration requires 438 square inches of floor space, 4930 cubic inches of total space, and weighs 354 pounds.

6 Volt Versus 12 Volt House Batteries (Continued)

- **In the Zephyr, Tiffin used to meet this need with eight 12 Volt Optima D31M batteries which provide 600 AmpHours of capacity (48 AmpHours less than the Bus configuration).**

- **This configuration requires 667 square inches of floor space (+52%), 6251cubic inches of total space (+27%), and weighs 480 pounds (+36%).**

- **Plus, the Optima batteries are Dual Purpose Batteries, not true Deep Cycle Batteries.**

6 Volt Versus 12 Volt House Batteries (Continued)

- **Other comparisons are shown in the chart on the next slide. In all cases, the 6 Volt battery configurations have significant advantages over comparable configurations of 12 Volt batteries with similar AmpHour ratings.**

6 Volt Versus 12 Volt House Batteries (Continued)

RV House Batteries - 6 Volt Versus 12 Volt

Battery	Volts	Amp Hours	Length (Inches)	Width (Inches)	Height (Inches)	Weight (Pounds)	Battery Type	Number of Batteries	Total Footprint (Sq. In.)	Total Space (Cu. In.)	Total Weight (Pounds)	Total Amp Hours	Notes
Lifeline GPL-6CT	6	300	10.28	7.06	13.02	90	Deep Cycle	4	290	3780	360	600	
U.S. Battery US 2000 XC2	6	216	10.25	7.13	11.25	59	Deep Cycle	6	438	4930	354	648	O.E. in Tiffin Allegro Bus
Lifeline GPL-4CT	6	220	10.28	7.06	9.92	66	Deep Cycle	6	435	4320	396	660	
Lifeline GPL-6CT	6	300	10.28	7.06	13.02	90	Deep Cycle	6	435	5670	540	900	
Optima D31M	12	75	12.77	6.53	9.37	60	Combo	8	667	6251	480	600	O.E. In Tiffin Zephyr
Lifeline GPL-31XT	12	125	12.90	6.75	9.27	74	Deep Cycle	5	435	4036	370	625	
Lifeline GPL-4DL	12	210	20.76	8.70	8.64	124	Deep Cycle	3	542	4681	372	630	
Lifeline GPL-31T	12	105	12.90	6.75	9.27	64	Deep Cycle	6	522	4843	384	630	
Lifeline GPL-8DL	12	255	20.76	10.89	8.64	156	Deep Cycle	3	678	5860	468	765	

Final Disclaimer

- **The information in this presentation is believed to be accurate as of April 2016.**

- **Please submit any corrections or suggestions to e-mail address: LarryBeckner@earthlink.net**